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MOC Work-in-Process Documentation—Best Practices

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1 Introduction

Management of Change, "MOC", is a complex business processes at chemical plants and refineries. In the U.S., MOC is required by a number of agencies including PHMSA, the EPA, and most commonly, OSHA. Various authors [1-4] have contributed to the knowledge of how to address the safety aspects of MOC.

Once a change request has been scoped out, as part of the Management of Change ("MOC") process, various individuals conduct the "design change" activities of the MOC. This involves creating new documents and revising existing documentation. MOC documentation is largely work-in-process ("WIP") information that may or may not ultimately become a part of the plant's operational data or process safety information.

Over the last two decades, plant documentation has increasingly been managed in electronic systems, due to the economic benefits of electronic document management. However, while many companies have an approach for managing currently released plant documentation, managing MOC work-in-process documentation is problematic due to its complexity: revision and version numbering issues, multiple concurrent modifications to the same P&IDs and other documents, not all MOCs are approved and implemented, temporary MOCs require that documented changes be "undone", etc.

This paper conducts a critical review of the various techniques for managing work-in-process documentation for MOCs and presents specific recommendations on best practices for MOC-WIP document management. Examples from actual installed systems are presented.

1.1 The Importance of Document Management to MOC

The Process Safety Management, "PSM", regulations regarding Management of Change, "MOC", explicitly refer to updates of Process Safety Information, "PSI", (emphasis added):

> (l) (4) If a change covered by this paragraph results in a change in the *process safety information* required by paragraph (d) of this section, such information shall be *updated* accordingly.

The section on Process Safety Information is very broad in scope, including:

(d) (1) Information pertaining to the hazards of the highly hazardous chemicals in the process…

(d) (2) Information pertaining to the technology of the process…

(d) (3) Information pertaining to the equipment in the process…

Altogether, there are more than 100 different information types that potentially need to be managed, as part of the MOC process, and these information types are contained in more than 50 common document types[5].

Despite the importance of the management of documents to the MOC process, there is a paucity of literature and research on this topic. This survey paper highlights important aspects of document management, as it pertains to MOC.

1.2 Revisions, Versions, Modifications

Many of the documents included in PSI are drawings. Common practice is to use a numeric or alphabetic sequence to identify revisions; e.g.

- Rev 0, Rev 1, Rev 2, …
- Rev 0, Rev A, Rev B, …
- Rev AA, Rev AB, Rev AC, …

A drawing revision typically goes through an approval process, and is thereafter "released" into production. An approved and released drawing would be considered a company record, and is subject to regulations governing records retention and disposition.

The path from approved and released revision "n" to approved and released revision "n+1" may have involved a number of intermediate instances. In the days of hardcopy document creation, each day (typically) that a drafter fastened the vellum or Mylar to his/her drafting table, a new "version" was created. No one was concerned with the formality of labeling these versions, since they were only apparent to the drafter.

In the world of electronic drafting, these intermediate files are saved on servers or electronic document management systems, and therefore the necessity of labeling versions arose, in order to distinguish for example yesterday's CAD file from today's CAD file.

When the changes to a set of versions have been completed and have gone through a review or approval process, then the final version (in this set) is considered the approved revision, and, again, becomes a corporate record.

In most design environments, revisions and versions evolve in a linear process as shown in Figure 1.

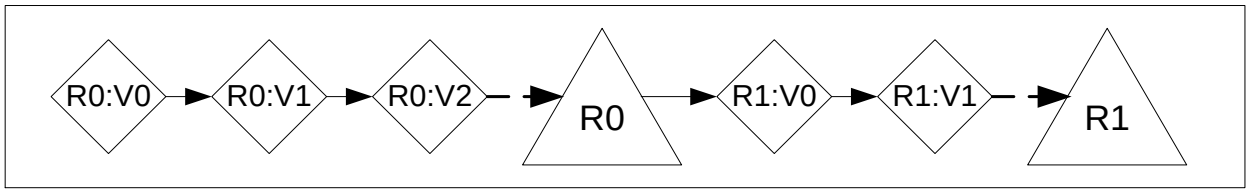

Figure 1. Linear evolution of revisions and versions.

A major difficulty arises in the domain of change management, because multiple changes may be made to the same base document. As shown in Figure 2, two copies—M0 and M1—are made of R0, and they are removed from the revision and version sequence. These copies, sometimes termed "modifications", commonly occur in capital projects, turnarounds, and MOCs.

The proposed changes, shown on these modifications, must be reconciled with the base drawings at some point. The reconciliation is often complex since the base drawings may have been revised since the modification was done. Figure 2 shows how modification M0 was made to revision R0. It may have taken months or years for the proposed change shown on M0 to be approved. When the M0 data is reconciled with the base drawing, the base drawing is already at revision R2, so the designer must take this into account.

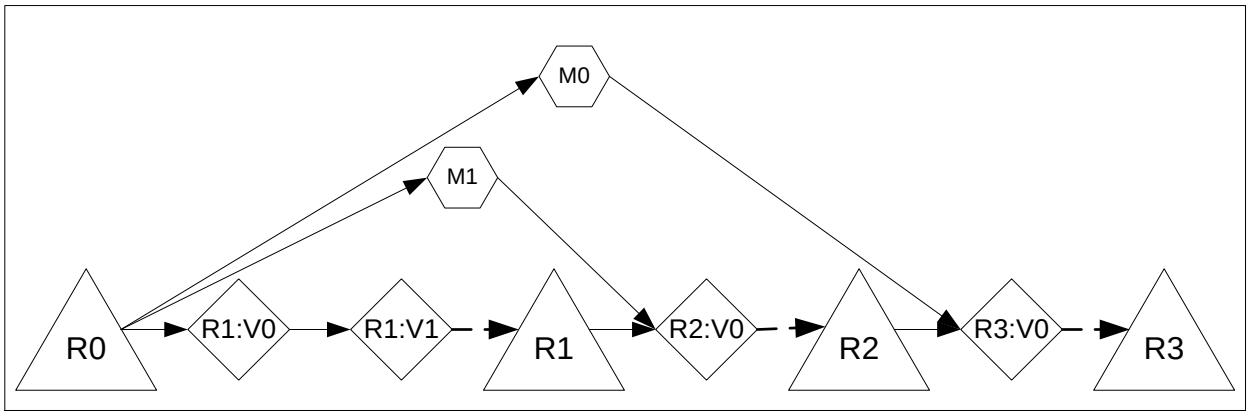

Figure 2. Multiple modifications to Rev. 0 of a drawing.

In the paper world, copies M0 and M1 of R0 were on paper, generally segregated into a separate filing system: project folders, turnaround folders, MOC folders. If one had a hardcopy of a drawing, it was usually difficult to know if the base document had changed. This is one of the reasons why ISO 9000 quality programs generally label hardcopies as "uncontrolled" or print an expiry date on hardcopies.

1.3 Documents vs. Attachments

At first glance, the terms "documents" and "attachments" appear similar. However, the implementations of documents and attachments are quite different and have a significant impact on how MOCs are processed.

1.3.1 Documents

A layman's view of "documents" is that they are written, printed or electronic matter that provide information or evidence. The concept of "documents" in electronic document management system encompasses the above, but also encompasses concepts of:

- information stored in a file
- file formats (e.g. .PDF), whereby different formats can be rendered differently, and using different tools
- revision and version history, as previously described. This is a requirement for audit trails on documents

- attributes, like “author”, “creation date”, “document number”, etc.
- an individual identify within the document management system allowing documents to be searched either by attributes or full-text search
- the ability to exist in folders or other document organizational structures
- the ability to have specific security and access control, beyond the security and access control of the parent MOC object

All electronic document management systems allow electronic information to be represented as “documents”, in this sense. As a consequence, since MOC is very document-centric, there are natural advantages to using an electronic document management system for the management of MOCs.

1.3.2 Attachments

“Attachments”, in contrast to documents, only have the following properties:

- information stored in a file
- attachment to some form or object, often an MOC form.

MOC packaged solutions—particularly those based on an electronic document management system—usually allow electronic information to be represented as “attachments”. The attachment approach is generally inadequate for MOC applications, since the work-in-process documentation is constantly being revised during the execution of an MOC.

Attachments also inherit security and access rights from the MOC. It is generally not possible to give attachments different access rights than the MOC itself. This becomes problematic when an MOC contains documents that embody trade secrets. When work-in-process information is contained in documents, in folders, the underlying EDM system can normally provide separate, and more restrictive, access control to the documents. When information is contained in attachments, separate, more restrictive, access control is usually not possible.

1.3.3 The Preferred Approach

The number of useful characteristics of the “document” approach outnumbers the useful characteristics of the “attachment” approach, which raises the question of why anyone would use the attachment approach for representing MOC WIP documentation?

The document-based approach is far more complex to develop and implement than the attachment-based approach. So, packaged solution vendors have shied away from this, since providing document management capabilities may be an order of magnitude more complex than simply providing packaged MOC functionality. For similar reasons, in-house developed MOC solutions have avoided the added complexity of creating a document-based solution for WIP document handling, and have tended to use attachment-based approaches.

The notable exceptions are those companies who provide an MOC solution as an application layered on an electronic document management infrastructure. While this approach has been used for over two decades—primarily by engaging consultants to create custom applications—there are now solutions in the market which use this layered application model.

2 Document Location

As indicated at the end of the previous section, hardcopy documents are difficult to control, once copies are made and used for purposes that do not fit within the linear evolution of revisions and versions.

Storage of these files on electronic media ought to offer some advantages, in this regard. There are two ways that intermediate instances can be managed: segregated or in-place. This discussion will be broadened to include all work-in-process documents used for MOC, not just drawings.

2.1 Segregated Management of WIP Documents

Segregated management of WIP documents is conceptually similar to what happens in the paper world, and is represented reasonably well by Figure 2:

- copies of relevant documents are made
- the copies are put into a folder, or structure of folders, identified by the particular MOC
- these copies can be modified, to suit the needs of the MOC

Since this folder environment is segregated from the location where official company records are kept, the modifications made to support the MOC process, do not disturb the properly released instances of the documents in the company filing system.

If these segregated documents are modified and the MOC is not approved, then the modifications simply remain in the MOC folders, and no further action is taken.

If these segregated documents are modified and the MOC is approved, then the modifications must be reconciled with the base documents at the appropriate time. This suggests that document changes occur in pairs:

- an initial modification, often called a “redline”, made prior to impact analysis and approval, to detail the proposed change, and,
- a final change to the base documents, sometimes called an “update”, made after the change has been implemented.

Segregated management of WIP documents potentially suffers from one of the same problems plaguing hardcopy document management: when a change is made to the base document, a person with a copy has no way of knowing. A change to the base document may have a safety or other impact on the MOC, so it would be beneficial if the MOC owner was aware that a base document has changed. Fortunately today’s electronic document management systems usually implement a “publish & subscribe” paradigm whereby a person (usually the owner of an MOC) can subscribe to a document (usually the base documents for those that have been copied into the MOC folders) and each time the document is modified (or even accessed, downloaded, or locked) the system sends the owner a message notifying him/her about the event. This overcomes that major problem of segregated management of WIP documents.

2.2 In-Place Management of WIP Documents

In-place management of WIP documents occurs as follows:

- the MOC owner, takes responsibility for the drawings or documents, as shown in Figure 1,
- if the technology supports it, then links to the affected documents are pasted into the MOC folders
- activating the links, or opening the original documents, permits the editing of the documents.

Although the MOC folder may be segregated from the rest of the company records, the WIP documents being changed are in the official company repository. While users with an operational need typically access the current released instances of the documents, most users would know where to find these work-in-process documents.

The in-place management of WIP documents has several problematic aspects—all of them can be overcome, but they dramatically increase complexity and are therefore detrimental to the user experience:

1. **Version labeling problems:** If proposed changes are shown on a new version of the document, and the change is approved, then the version showing the proposed change must be promoted to a new revision. If the proposed changes are not approved, then the version showing the proposed change must be "undone" in some manner. This "undoing" will create a new version of the document, and that is confusing to the user:
   a. Rev 1, Version 0 doesn't show proposed change X
   b. Rev 1, Version 1 shows proposed change X
   c. Rev 1, Version 2 doesn't show proposed change X

   A person may ask why it is not possible to return to version 0. Most electronic document management systems only permit increasing version numbers.

2. **Timing problems:** A given document may have multiple proposed changes applied to it. Considering Figure 2, imagine that the MOCs represented by M0 and M1 were done at the same time. The document would show both of these proposed changes on an intermediate version (like R1:V1). At some point M1 is implemented, so it's necessary to finalize the M1 changes in the document, and approve them as Rev 2. What would one do with the proposed changes associated with M0, which are actually in the file? Leave the proposed M0 changes as redlines? What if the M0 redlines pertain to equipment that was actually removed by M1?

These 2 issues have discouraged the adoption of in-place management of WIP documentation.

3 Document Organization

An MOC may cause the modification of many documents. Whether segregated or in-place management of WIP documents is used, some approach must be adopted to organize the work-in-process documents. A common approach is to set up a folder structure for each MOC.

Based on an inventory conducted by Hoff[6], the number of documents redlined during an MOC range from three (at the 10^{th} percentile level) to five (at the 50^{th} percentile) to 12 (at the 90^{th} percentile). There are an additional two to three times as many supporting documents, including impact analyses, standard forms and templates, and so on. So the total number of documents in an MOC is in the range from 10 to 50 documents.

To properly house this volume of documents, a small number of folders would be adequate. A common, but by no means the only, structure for MOC documents is as follows:

1. Background information
2. Design data
3. Impact analysis
4. PSSR documentation

In theory, one could have folders within folders. But, a folder hierarchy always involves increased navigation for the user, so that should be avoided for the modest number of documents being considered.

A related issue is the use of MOCs during capital projects. It is true that many large projects, perhaps even in the billions of dollars, are performed under the umbrella of the MOC process. But capital projects have their own management structure, and have their own document repositories, separate and apart from MOCs. So it is very unlikely that the MOC folder structure would be used to provide a repository for capital project data. A more detailed discussion of the relationship between MOC and capital projects can be found in [7].

So the MOC folder structure should be kept simple and optimized for typical MOCs, which have less than 50 supporting documents.

4 Forms and Templates

As the business processes at a facility mature, it is quite common for knowledge to be standardized in "forms" and "templates". These words are often used interchangeably, although the electronic document management community would probably differentiate them as follows:

- Forms: Forms are created in an electronic system with the intent that they be completed in their electronic form. A form usually has a number of fields, and the data in the fields is searchable, sortable and reportable. Often, the data on a single form is represented by a row of data in a table or list.
- Templates: Templates usually originated as documents. Templates are often still used in a hardcopy mode. In order to keep track of completed templates, they may be scanned and the files put in the proper MOC folders. Checklists are generally in this category as well.

The definitions, above, are not rigorous or immutable; they are simply guidelines.

While there may be many templates the common types of templates, in the MOC context, are:

- Engineering aids: These are templates that a person might complete in order to assist with the design work. For example, if an MOC involves relief valves, there may be a relief valve template that ensures the key aspects of relief valve design have been addressed.
- Impact analysis aids and checklists: Depending on the risks of the MOC, various checklists or other templates may need to be completed, e.g. PHA checklist.
- Calibration checklists: Once certain kinds of equipment or instrumentation are installed, they may need to be calibrated. A calibration checklist is an aid in this process.

- Inspection checklists: Certain kinds of equipment or other assets may need to be inspected, as outlined in procedures and other relevant checklists.
- PSSR checklists: The pre-startup safety review normally involves the use of a number of checklists.

These forms and templates are usually considered WIP documents—and they would most certainly be considered corporate records when the MOC is complete—so it makes sense to properly manage these as well.

4.1 Leveraging Electronic Document Management Systems to Manage Templates

Electronic document management systems offer several benefits in the management of templates. First, an EDM system can provide a central repository of templates. In order for a central template repository to be reliable and authoritative:

- Proper access control must be enabled: While many companies, departments and even workgroups have created their own websites in the past, which may have stored official company templates, providing such a facility with an EDM system, requires a more complex implementation. EDM system have more granular access control and it's important to ensure that the potential user community is provided the proper access.
- The template repository must be maintained: someone must take responsibility for ensuring that the templates in the repository are the currently released versions.

The second way to leverage EDM systems is to take advantage of their integration with desktop applications like word processors and spreadsheets. Since, controlled documents, and especially templates, have standard header attributes, these ought to be automatically populated by the EDM system. This avoids the user having to complete the header him/herself, and avoids the problems of potentially conflicting data between the two instances (i.e. the template document, and the EDM system).

5 Optimizing the Use of Paper Documents

Over the course of an MOC's lifecycle many documents must be populated into the MOC folders, as discussed in the prior section. At times, it is either required or more practical to conduct the business process using a hardcopy document, rather than an electronic template (see previous section). Two factors commonly trigger the need for paper documents:

- Timing issues
- Work, away from a computer

5.1 The Need for Paper Documents

5.1.1 Timing Issues

Sites use various approaches to dealing with electronic MOCs. More sophisticated approaches commonly use lifecycle-based applications or workflow tools to move an MOC through its lifecycle.

If a certain activity in the MOC process requires signatures, then the electronic process simply stops and waits for all the signatories to complete their respective tasks. This becomes problematic in the case of, say, operator notification. There may be 24 operators for a unit. Obtaining all 24 signatures may take weeks, so the MOC fails to progress until all the signatures have been gathered.

From a safety and regulatory perspective, it's only necessary to train the on-shift operators, and maintain records thereof. One practical approach is to have a printed sign-off sheet in the control room with access to (a paper or electronic copy of) the MOC. As operators[1] come on-shift, they review the MOC, sign the sheet, and carry on with their work.

Once the sign-off sheet has all the signatures, it can be scanned and put into the MOC folder. In the meantime, the MOC process can proceed with other tasks.

5.1.2 Work, Away From a Computer

At various times documents, which are important to an MOC, must be completed in the facility, where it may be impractical or impossible to take a computer or other technology necessary to fill in electronic forms. Examples include:

- Pre-startup Safety Review ("PSSR") forms
- Pre-commissioning and commissioning checklists
- Calibration forms
- Inspection forms
- Drawings, used for recording as-built information.

Using PSSR forms as an example, OSHA discourages the conduct of PSSRs simply by sitting at a computer and filling in a form. The PSSR assignee should go into the facility and complete the form as the safety review is taking place. This necessitates the use of a paper form.

Just like the case of training sign-off sheets, described in the previous section, PSSR forms should be scanned and entered into the proper MOC folder.

5.2 Overcoming Problems with Paper Documents

All paper documents suffer from the common problems of:

- they are easy to lose or misplace,
- there is generally only one copy of the paper document, used in a business process, so multiple people cannot see the status of a given document, and,
- it is usually difficult to know exactly who has the physical document in his/her possession.

Once paper documents become part of an MOC process, then these problems cannot be avoided. They can, however, be minimized. And that entails using the document, in its hardcopy form, for the least possible duration: print it, use it, scan it back in.

[1] Although "operators" are used in this example, the same logic applies to maintenance, contractors, and any others who may need to be trained on MOCs.

Two additional issues, associated with using paper documents in MOCs, are:

- filing/misfiling issues
- dealing with multiple instances of the same template

5.2.1 Filing/Misfiling Issues

When a completed template has been scanned, it must be filed into the proper MOC folder. This can be a time-consuming process. Although the scan-and-index task can be assigned to clerical staff, there is no guarantee that these resources are available, or are available when needed.

Filing of any document can be error-prone. Misfiled documents can be more difficult to find in an electronic system, than in a paper folder system.

One solution to difficulties with filing/misfiling is to imprint the forms with bar codes signifying:

- the document type, e.g. PSSR
- the parent object, e.g. MOC-1234

The barcoding would be done automatically by the electronic document management system instantiating the template. Once the person has completed the, say, PSSR, the hardcopy could be scanned and emailed to a specific email address. The email address is designed to open attached documents and file them in the appropriate (in this case, MOC) folders.

5.2.2 Dealing With Multiple Instances of the Same Form

Suppose a single MOC involves the replacement of three tank level controllers. The controllers are identical, and each needs to be calibrated once installed. The calibration is recorded on the "Tank Level Controller Calibration Sheet".

While the calibration records may be stored or archived in the Inspection or Maintenance Department, the calibration sheet may be generated by the MOC system, and a copy may be stored in the MOC files.

The difficulty arises with the fact that electronic MOC systems typically use links to point to documents. Since there are three calibration documents, which one is pointed to by the link the MOC system?

To avoid confusing the user, the eMOC system requires a mechanism to distinguish between multiple instances of the same type of document or template.

6 Summary

Management of Change is a very document-centric process, yet little has been written about best practices for managing documents in the MOC context. This survey article reviews the key issues associated with the topic. These include:

- dealing with revisions, versions and modifications
- differentiating between documents and attachments, and why documents are more suited to MOCs
- deciding on whether to leave the documents where they are filed (in-place management) or segregating the WIP documents into separate folders

- the benefits of organizing MOC WIP documents into folders, including security implications
- improving MOC performance through the use of (often existing) forms and templates
- deciding when it is necessary to use a hardcopy instance of a document, rather than an electronic version
- overcoming the limitations of hardcopy documents, in cases where they are needed.

Each of these topics is worthy of further research, particularly in regards to how these issues may be applied to improve the performance of the MOC business process, or, more generally, any document-centric business process required for PSM (e.g. incident investigation, audit management, action item management).

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